

Heat and optics

Heat ① Heat Transfer.

② Kinetic theory of gases.

③ 1st law of thermodynamics

Heat Transfer

→ 3 ways to transfer heat

1) Conduction.

2) Convection.

3) radiation → Vacuum.

→ Heat Transfer without
and molecules don't transfer



In metals free electrons + molecules

Thermal conductivity

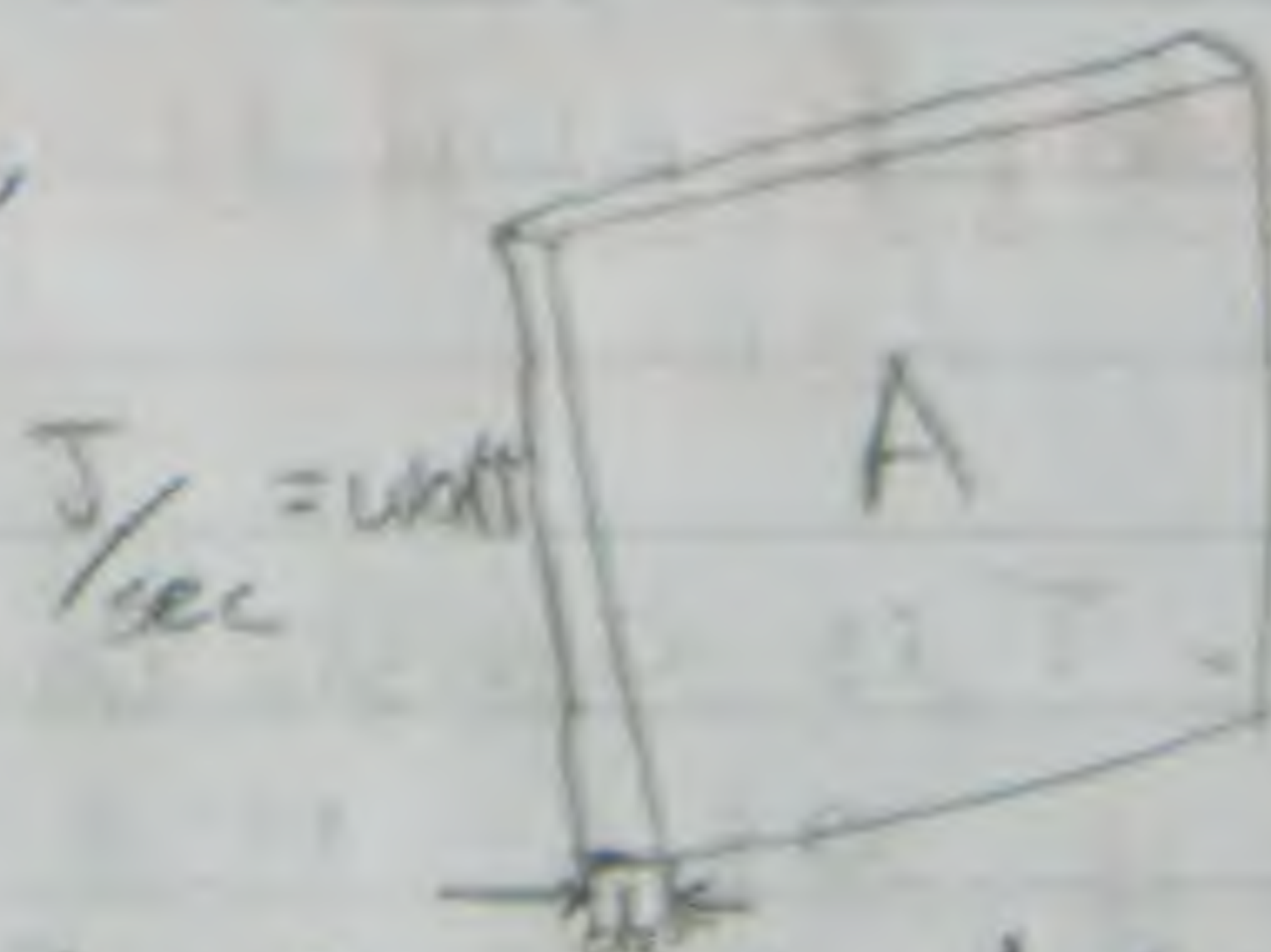
Heat current: The amount of heat that across the section of this material in one second.

$$H = \frac{Q}{t}, \quad H = \frac{Q}{t} \times A,$$

$$H = \frac{Q}{t} \times \frac{dT}{dx}$$

$$\frac{dT}{dx} = \text{Temp gradient.}$$

(gradient is any change with distance).



→ Thermal conductivity

$$H = \frac{Q}{t} = KA \left(-\frac{dT}{dx} \right).$$

The amount of heat per unit time flowing normal to the face of unit area of the material to cause unit Temp. gradient.

$$K = \frac{H}{A \left(-\frac{dT}{dx} \right)} \quad (\text{coefficient}).$$

$$[H] = \text{watt} \quad [K] = \frac{\text{watt}}{\text{m}^2 \cdot \frac{^\circ\text{K}}{\text{m}}} = \text{watt} / \text{m}^\circ\text{K}.$$

$$1 \text{ Calorie} = 4.186 \text{ Joule}.$$

$$[K] = \text{Cal s}^{-1} \text{cm}^{-1} \text{K}^{-1} \Rightarrow \text{lap}.$$

• Good conductors

metals: Cu, Ag, Al

• Bad conductors

metals: wood, wool, glass, ebonite.

Note heat Transfer from greater heat to less.
as (from hand to keys).

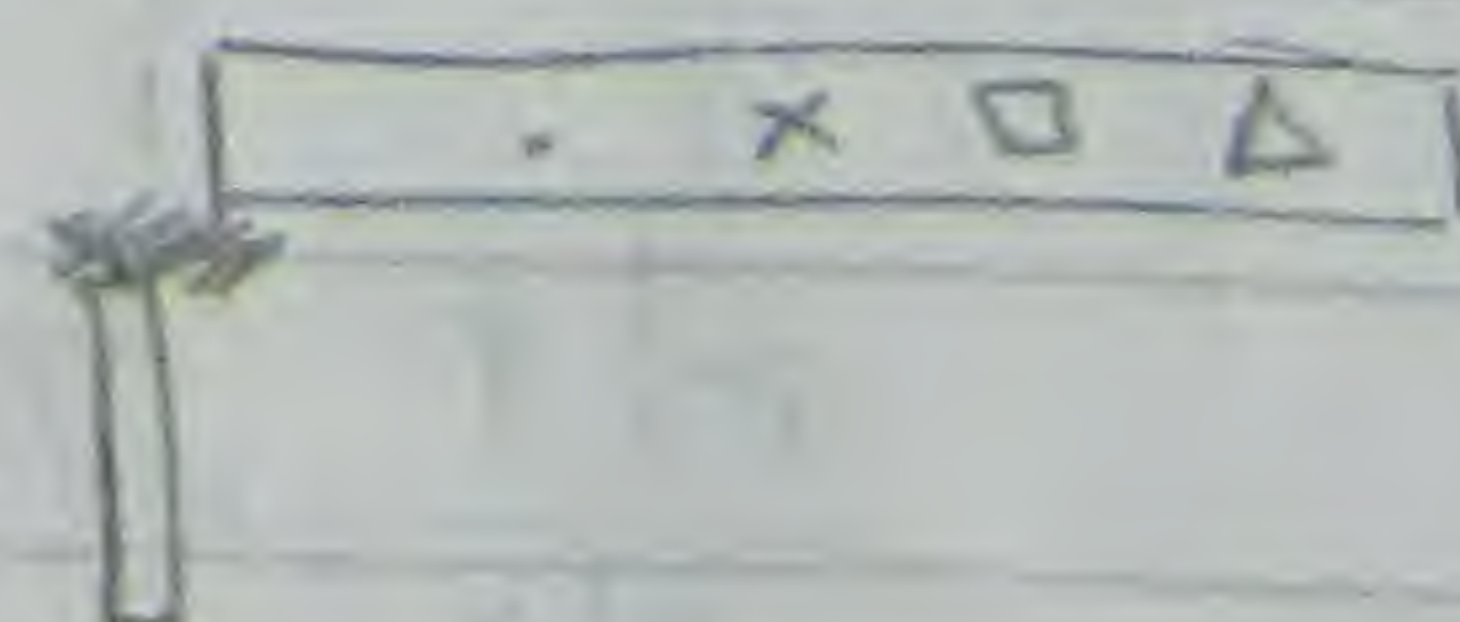
Steady flow of heat

T : Const with time.

T : may vary with position.

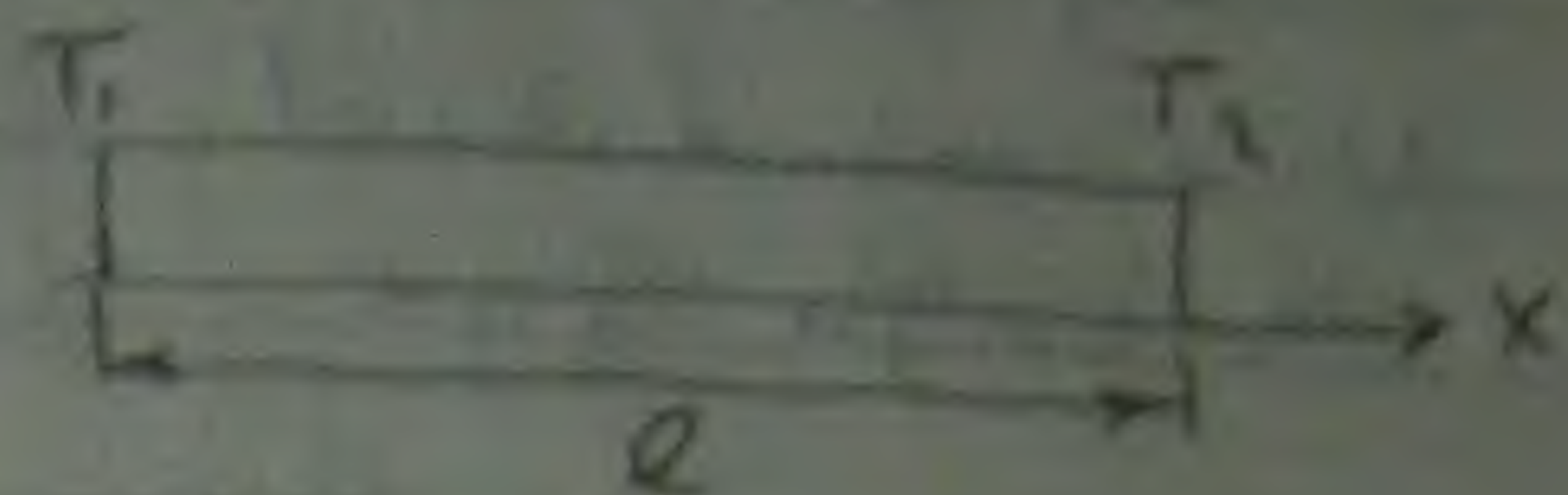
- T is const in a given position
as (• or x)

- T is vary from among (•, x, Δ, □)



Uniform bar

$$H = \frac{Q}{t} = -KA \frac{dT}{dx}$$



$$\int_{T_1}^{T_2} dT = -\frac{H}{KA} \int_0^l dx$$

$$T - T_1 = -\frac{H}{KA} x$$

$$T = T_1 - \left(\frac{H}{KA}\right) x \Rightarrow (1)$$

$$\int_{T_1}^{T_2} dT = -\frac{H}{KA} \int_0^l dx$$

$$H = \frac{KA}{l} (T_2 - T_1) \Rightarrow (3)$$

$$T_1 - T_2 = \frac{-H}{KA} l \Rightarrow \text{Relation between } T_1 \text{ and } T_2 \quad (2)$$

By (1) and (2)

$$\frac{H}{KA} = \frac{T_1 - T_2}{l} \Rightarrow (4)$$

By (1) and (4)

$$T = T_1 - \left(\frac{T_1 - T_2}{l}\right) x$$

By (1)

$$H = \frac{Q}{t} = \frac{T_1 - T_2}{l/KA} \Rightarrow \text{as ohm's law}$$

$$i = \frac{Q}{t}$$

Q = amount of charge
 t = Time

i = electric current

$$i = \frac{V_1 - V_2}{R}$$

$$H = \frac{Q}{t}$$

Q = amount of heat
 t = Time

H = heat current

$$H = \frac{T_1 - T_2}{l/KA}$$

$$R = \frac{l}{KA}$$

Steady flow of
viscous liquid
through a pipe

$$Q = \frac{\Delta P \pi a^4}{8 \eta l} = \frac{\text{Vol.}}{\text{Time}}$$

$$Q = \frac{\text{Volume}}{\text{Time}} = \frac{\Delta P \pi a^4}{8 \pi \eta \left(\frac{l}{\pi a^2} \right)}$$

$$Q = \frac{\text{Force}}{8 \pi \eta \left(\frac{l}{A} \right)}$$

⇒ Force causing the
motion

⇒ $8 \pi \eta$: Viscous
Resistivity

⇒ $8 \pi \eta \frac{l}{A}$: Viscous
Resistance

Steady flow
of Heat

$$H = \frac{Q}{t} = \frac{T_1 - T_2}{l / KA}$$

⇒ $\frac{l}{KA}$: Thermal
resistance

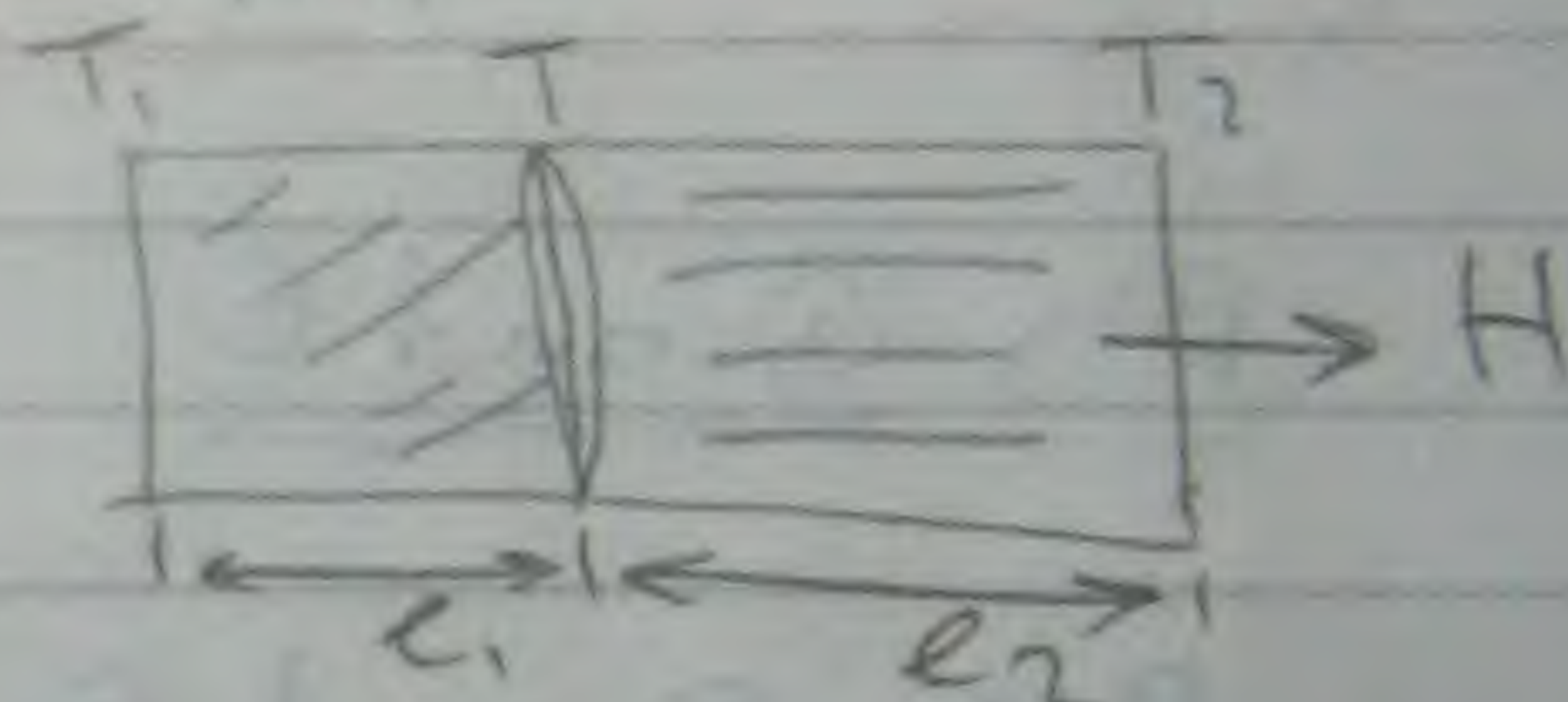
Steady flow
of charge

$$i = \frac{Q}{t} = \frac{V_1 - V_2}{R}$$

$$R = \frac{l}{\sigma A}$$

$$R = \rho \frac{l}{A}$$

⇒ Compound wall



$$H = \frac{T_1 - T}{R_1} \quad \text{--- (1)}; R_1 = \frac{l_1}{K_1 A}$$

$$H = \frac{T - T_2}{R_2} \quad \text{--- (2)}; R_2 = \frac{l_2}{K_2 A}$$

$H \Rightarrow \text{Const } A_1 = A_2$
($T_1 > T > T_2$)

$$T = \frac{R_1 T_2 + R_2 T_1}{R_1 + R_2}$$

By (1), (2)

$$H R_1 = T_1 - T, H R_2 = T - T_2$$

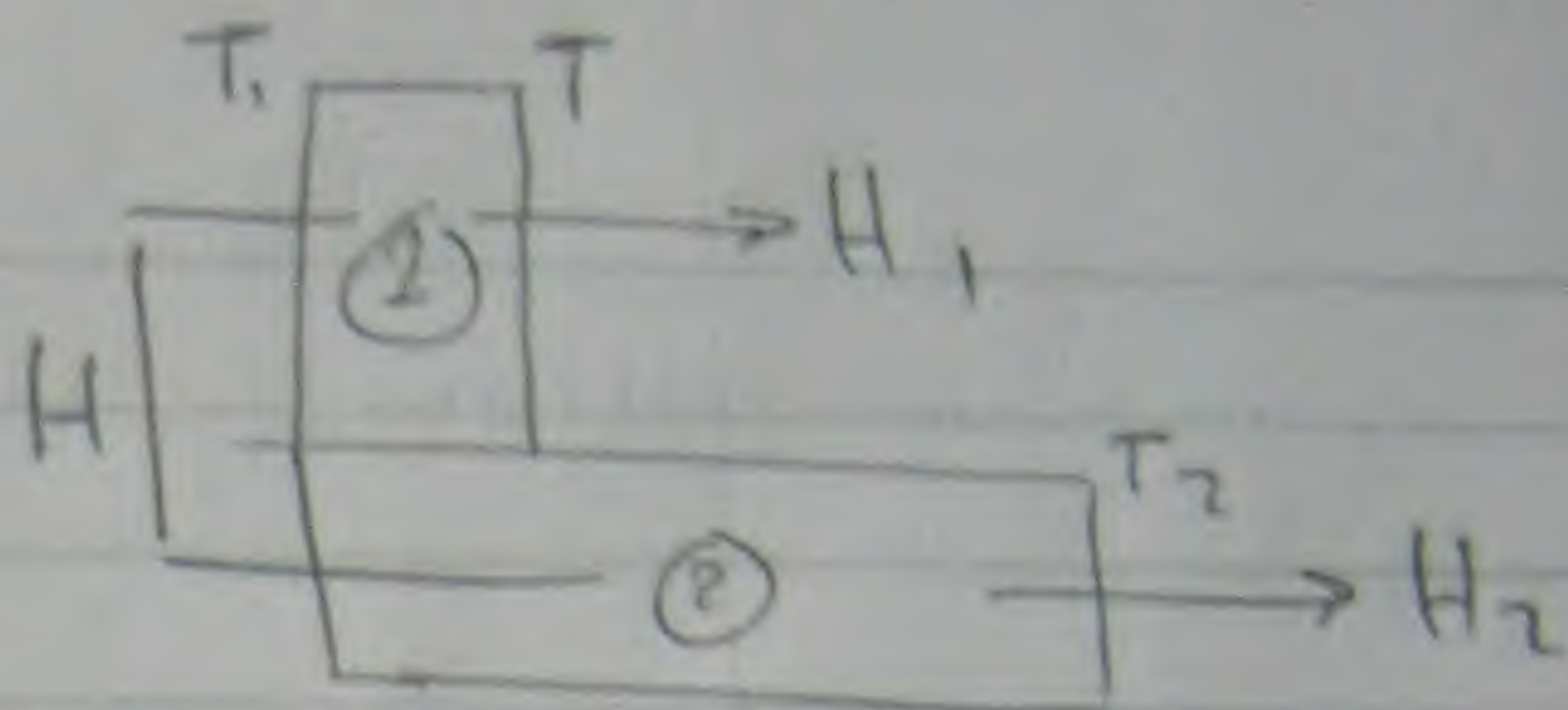
by addition

$$H (R_1 + R_2) = T_1 - T_2$$

$$H = \frac{T_1 - T_2}{R_1 + R_2} = \frac{T_1 - T_2}{R}$$

$R = R_1 + R_2 \Rightarrow$ series
connection

② Common edge



$$H = H_1 + H_2$$

$$(1) - H_1 = \frac{T_1 - T_2}{R_1}, \quad H_2 = \frac{T_1 - T_2}{R_2} \quad (2)$$

addition of (1+2) $H = H_1 + H_2 = T_1 - T_2 \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$

$$H = \frac{T_1 - T_2}{R}$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \quad (\text{Parallel connection}).$$